Symmetry-Based Classification of Exact Flat Bands

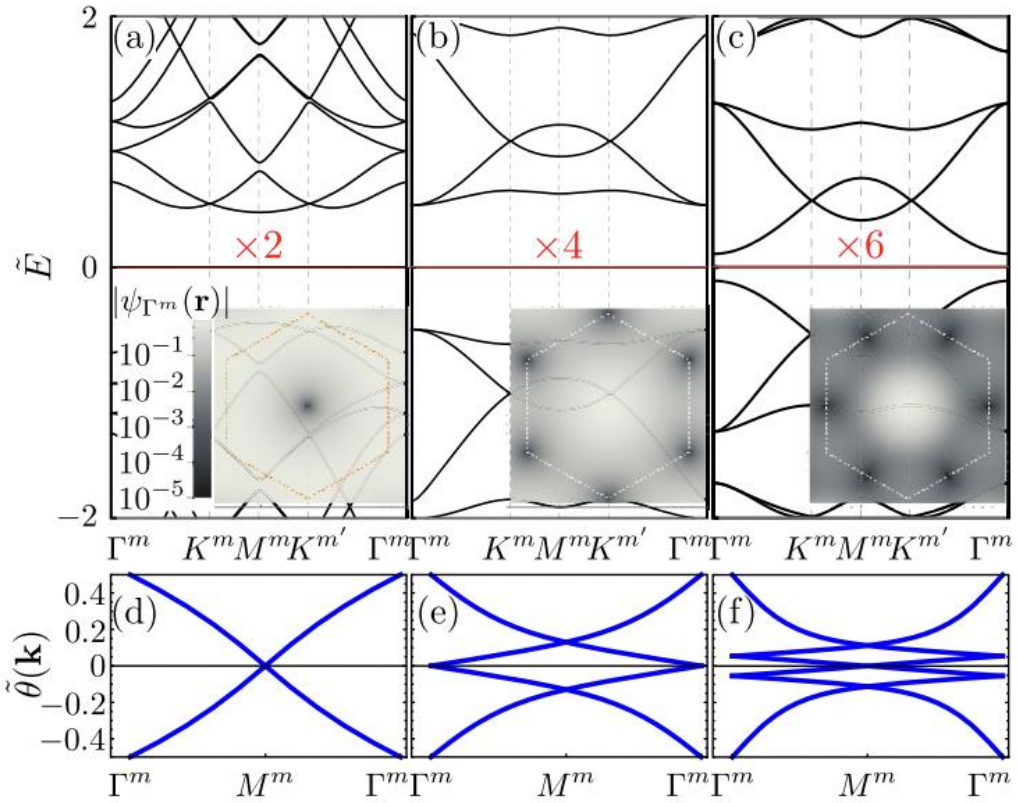

Figure: This shows how applying special strain patterns to a material can produce multiple perfectly flat electronic bands, where electrons behave as if they have no kinetic energy.

Scientific Achievement

Development of a new way to understand how completely flat energy bands — key to many exotic quantum behaviors —can form in advanced layered materials known as moiré systems.

Significance and Impact

This work provides a clear roadmap for creating and controlling flat energy bands in quantum materials, which are essential for realizing exotic phases like topological states. It opens new paths for engineering next-generation electronic and quantum devices.

Research Details

- Developed a symmetry-based classification for exact flat bands in single and bilayer moiré materials with Dirac or quadratic band crossings.
- Constructed exact wavefunctions demonstrating that these flat bands can have ideal quantum geometry and a total Chern number of 1.
- Linked the geometry of wavefunctions (zeros at high-symmetry points) to the emergence of topological flat bands.
- Demonstrated that groups of these flat bands behave like generalized Landau levels, supporting novel quantum phases.

Sarkar, S.; Wan, X.; Lin, S.-Z.; Sun, K. Symmetry-Based Classification of Exact Flat Bands in Single and Bilayer Moiré Systems. *Physical Review Letters*. 2025.

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